# Lichens as biomonitor of environmental changes in the Northwest European Russia

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## INTRODUCTION

Numerous studies have shown that aerosols are of importance for atmospheric chemistry and climate of the Arctic [Pacyna, 1991; Barrie, 1996; Leck et al., 1996; Shevchenko et al., 2003]. At the coasts of Arctic seas and in their catchment areas delivery of chemical elements and compounds are registered in natural archives, for example in lichens. Lichens absorb substances, including trace elements, through dry and wet deposition, and have been widely used as biomonitors [Conti and Cecchetti, 2001; Garty, 2001; Walker et al., 2003].

## MATERIALS AND METHODS

We studied multi-element composition of terricolous (mostly of genera *Cladonia* and *Cetraria*) and fruticose epiphytic (mostly of genera *Alectoria*, *Usnea* and *Bryoria*) lichens collected in 2004–2009 in Kola Peninsula, Karelia, Arkhangelsk Region and Komi Republic of NW Russia, mostly in the frame of International Polar Year activity (Fig. 1–4). About 110 samples were analyzed. The unwashed lichen samples were air dried and homogenised to a fine powder in an agate crusher. Samples were treated in a four-step chemical digestion procedure (full dissolution via acid attack) for inductively coupled plasma spectrometry. Element concentrations were determined by inductively coupled plasma-mass spectrometry (ICP-MS). Parts of dry samples were analyzed by instrumental neutron activation analysis (INAA). An enrichment factor (EF) was calculated for each element (X) relative to the composition of earth's crust: EF = ((X/Al) in lichen) / ((X/Al) in the earth's crust [Rudnick and Gao, 2003]). Al was used as a crustal indicator.

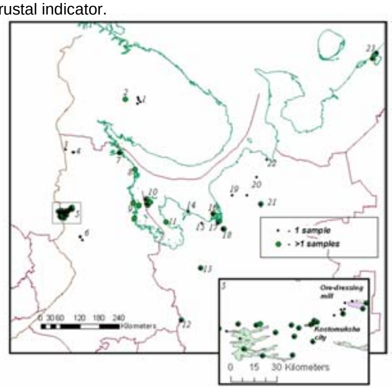


Fig. 1. Sampling sites:1 – Lovozerskie Tundry; 2 – Umbozersky Pass, Khibiny; 3 – Paanayarvi Lake; 4 – Kivakka; 5 – Kostomuksha area; 6 – Muezersky district, Karelia; 7 – Kartesh Cape; 8 – Gridino; 9 – Kem' District; 10 – Solovetsky Islands; 11 – Onezhsky Shore; 12 – Kenozersky National Park; 13 – Kleschevo; 14 – Unsky Lighthouse; 15 – Kurtyaevo; 16 – Kumbysh Island; 17 – Bank of Laya River; 18 – Ilasskoe Bog; 19 – Bank of Kepina River; 20 – Bank of Soyana River; 21 – Bank of Karmozero Lake; 22 – Abramtsevsky Shore; 23 – Kolokolkova Guba.

Fig. 2. Terricolous lichens *Cladonia sp*. in Northern Karelia.

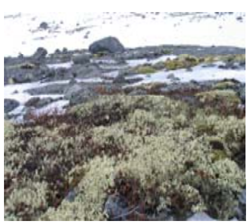

Fig. 3. Terricolous lichen *Flavocetraria nivalis* at Umbozersky Pass, Kola Peninsula.

Fig. 4. Epiphytic lichen *Alectoria sarmentosa* in Kostomuksha District.

## RESULTS AND DISCUSSION

In most samples contents of Ti, V, Cr, Fe, Co, rare earth elements (REEs), Th, U are at the background level and their EFs are less than 10 (Fig. 5). These low EF values indicated that, relative to average values for crustal rocks, there was no enrichment of these elements in the lichen concerned. For some elements (Cd, Zn, Sb, Pb, Mn, As, Ni, Cu) consistently higher EF values were obtained. These higher values were interpreted in terms of sources of both anthropogenic and natural sources other than crustal rock and (or) soil. These elements could be derived by long-range atmospheric transport. Highest concentrations of Cu, Ni, Pb in lichens and EF by these elements were registered not far from Monchegorsk and Nickel Cu-Ni smelters (Kola Peninsula). The Ni/Al ratio could be used as indicator of Monchegorsk smelter influence on the terricolous lichen elemental composition. The highest values of this ratio were registered not far from Monchegorsk (Fig. 6). In the vicinity of Kostomukshsky Ore-dressing Mill contents of Si, Fe and many lithogenic elements in terricolous lichens are relatively high, but at the distance more than 20 km they sharply decreased (Fig. 7 and 8) due to contamination by dust from the mill; the content on Zn and many trace elements doesn't change strongly (Fig. 9). The contents of studied elements in epithytic lichens in Kostomuksha District are close to background level. In lichens collected at the White and Barents sea coasts, high Na content and EF values were revealed.

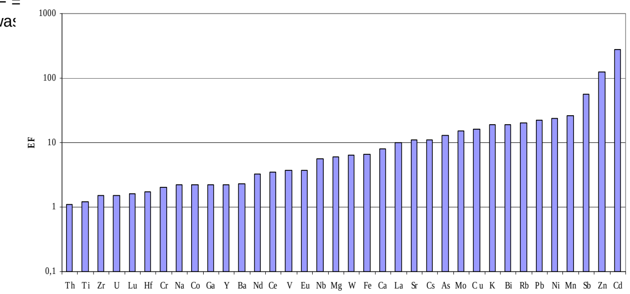


Fig. 5. Average enrichment factors (EF) of terricolous lichens.

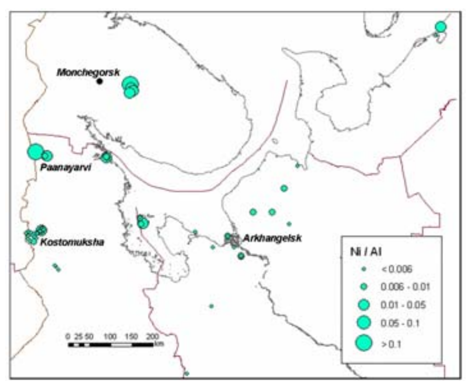


Fig. 6. Ni/Al ratio in terricolous lichens.

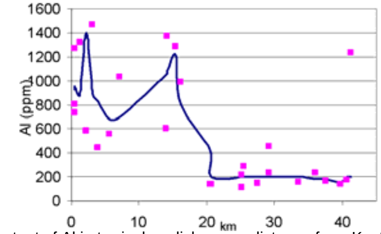


Fig. 7. Content of Al in terricolous lichens vs distance from Kostomukshsky Ore-dressing Mill.

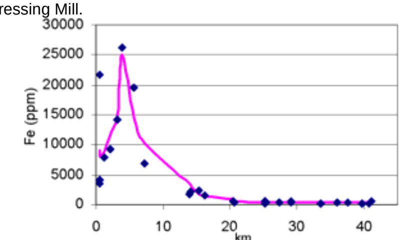


Fig. 8. Content of Fe in terricolous lichens vs distance from Kostomukshsky Ore-dressing Mill.

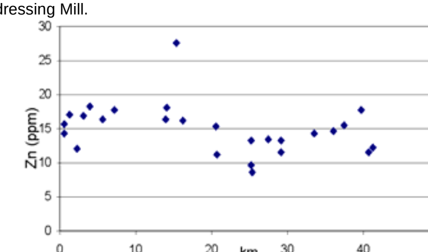


Fig. 9. Content of Zn in terricolous lichens vs distance from Kostomukshsky Ore-dressing Mill.

## CONCLUSION

In general, elemental composition of lichens in the Northwest European Russia reflects complex influence of atmospheric deposition of aerosols from both natural and anthropogenic sources.

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